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GROUNDING, BONDING AND SHIELDING BIBLIOGRAPHY 1971 TO 1975.(U)

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FEDERAL AVIATION ADMINISTRATION
WASHINGTON, D. C.

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Final Report

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16. Abstract

As a result of a literature search carried out in conjunction with an extensive effort concerning grounding, bonding and shielding, a bibliography was compiled. The bibliography, covering the period 1971 to 1975 is contained in this report. A bibliography covering the period 1930 to 1971 was published as a separate report, FAA-RD-76-145.

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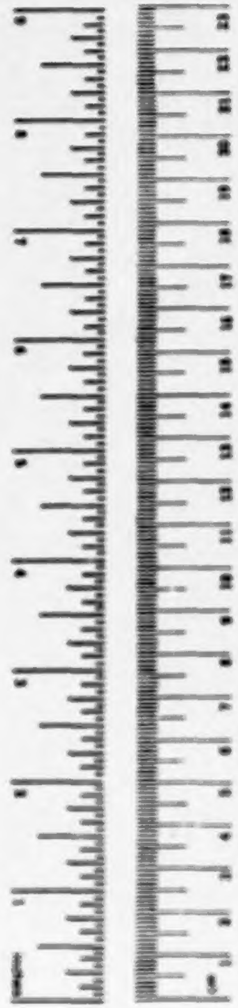
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

Calculating the Resistance and the Potential Distribution of a System of Annular Electrodes in a Non-uniform Two-layer Medium; A. M. Arekelyan, D. V. Arutyunuan, R. O. Gabrielyan - Elektrichestro (USSR); English translation in: Elec.Tech. USSR (GB), Vol. 4, p. 138, 1971.

This method simplified the computation of the resistance and potential distribution or earthing in proposing an estimation model which is constructed by representing a conducting plate which is bent into cylindrical shape and closed at the top by a disk, as a system of co-axial electrically-coupled concentric rings which is shown applicable to a wide range of earthing variants.

On the Thermal Stability of Earthings; K. R. Rakhimov - Elektrichestro (USSR), p. 75-7, No. 10 (1971) in Russian. English translation in: Elec.Technol. USSR (GB), Vol. 4, p. 138 (1971).

This article considers the various reasons for thermal instability of earthings due to temperature rise and the phenomenon of "thermo-capillary conduction" whereby thermal damage is believed to arise from a movement of moisture towards the heat flux in moist capillary bodies (porous) in addition to the expected drying of the ground. A criterion is proposed which should be taken into account besides the temperature rise of the ground in the verification of earthings.

Use of Shields with an Aperture of a Spherical Shape for One-dimensional Mode Analysis of Quasi-optical Fields; A. A. Dyachenko, p. 842-4 in Russian. English translation in: Radio Eng. & Electron. Physics (USA), Vol. 16, No. 5, p. 860-3 (May 1971).

High Voltage Lightning Grounding Device; V. S. Peterson and R. G. Hoffman, Lewis Research Center, 2100 Brookpark Rd., Cleveland OH 44135 - NASA Technical Brief, May 1971, Brief 71-10137.

This article describes a transient grounding device to be used in preventing lightning-induced high voltage transients from reaching the inputs or outputs of solid state instruments and control systems. Also described is the necessary modification of terminal blocks for the insertion of the transient grounding device in wire termination cabinets commonly used in large facilities.

The transient grounding device was successfully tested at 10 KV and 10 joule strike levels; the highest energy level that can be present in this type of wire terminal block, before the transient, arcs over the block and finds its own path to earth.

The device is described and the circuit diagram is given. The elements required for constructing the device are: three gas filled spark gaps, two ferrite core chokes and a zener diode.

Shielding by Soft Magnetic Materials; F. J. Young, D. J. Boomgaard (Westinghouse Res. Labs., Pittsburg PA, USA) - AIP Conference Proc. (1971), 17th Annual Conference on Magnetism and Magnetic Materials, Part II, Chicago IL, USA, 16-19 May 1971.

Transfer impedance measurements are performed on several Ni-Fe tubes over the frequency range of 10 to 3.2×10^7 hertz. The influence of axial dc magnetic fields is studied. A limiting nonlinear model is devised to explain and predict the behavior of soft magnetic material used to shield against current in coaxial configurations. The new model relates to the basic dc magnetic fields is studied. A limiting nonlinear model is devised to explain and predict the behavior of soft magnetic material used to shield against current in coaxial configurations. The new model relates to the basic dc magnetic and electrical properties of the material, saturation induction, initial permeability, electrical conductivity and the magnitude of the applied magnetic field.

Spheroidal Electromagnetic Screens; S. V. Zhukov, L. A. Tseitlin - Radiotechnika (USSR), p. 50-55, in Russian; English translation in: Tellecommun. Radio Eng., Pt. 2 (USA), Vol. 26, No. 8, p. 93-97 (Aug. 1971).

The magnetic fields of thin-walled conducting nonmagnetic spheroidal shells, produced by the action of an external varying magnetic field are discussed.

Role of Earthing in Industrial Electrical Installations; P. H. Padhye (Humphrys & Glasgow Consultants, Bomba, India) - Elec. India, Vol. II, No. 12, p. 13-20 (Dec. 1971).

The object of this article is to put forward views, observations and suggestions concerning earthing to the members of the Electrical Contractors Association for review and comments. It is felt that exchanging ideas on such subjects of importance would benefit all concerned in the trade and improve the standard of work as well as safety.

Electrical Grounding Bracket; Technology Utilization Officer, Ames Research Center, Moffett Field CA 94035 - NASA Technical Briefs, 1972, Brief 72-10045.

The brief describes a specially shaped bracket which fits around a typical multiple-pin connector and supports a grounding bar to which shield ground wires can be fastened. It is simply a rigidly supported, rounded strip of metal onto which may be soldered the shieldground leads of the shielded wires leading to the connector pins.

The electrical grounding bracket simplifies solder operations and the dressing of shield terminations. Because each shieldground lead can be soldered independently to the bracket, it is a simple matter to alter the wiring configuration of the connector or to remove or add shielded wires. The bracket also permits addition or deletion of a ground circuit without disturbing the remaining ground wires, and the grounding bracket may itself be unfastened from the connector for electrical tests.

PME at Avonbank; C. C. Brazier - Proc. of the 1971 Electrical Installation Conference, London, England, Nov. 30 - Dec. 1, 1971 (London, England: Peter Peregrims LTD., 1972) p. 160-9.

The Proceedings of the 1971 Electrical Installation Conference concerning the electrical installation at Avonbank is described. To the author's knowledge, this is the first building to be wired under a modified standard earth sheath return wiring constant. It is felt that this type of wiring can speed up installation because it reduces the numbers of conductors required. An extension of this approach, namely, PME, coupled with all insulated conduit and ducting systems, can lead to worthwhile economies.

Determination of Line Earth-return Wire Cross-sections with Regard to their Thermal Stability; L. Genov, B. Siromakhov and V. Velichkov - Electrical Technology USSR (GB) Vol. 2, p. 167 (1972), translation of Elektrichestro (USSR), Vol. 2, No. 4-6, p. 17-20 of No. 4 (1972).

An algorithm is proposed for evaluation of the parameters of aluminum-steel earth-return wires on transmission lines, having regard in particular to the thermal stability and mechanical strength of the earth-return wires. The approach to the nearest substation is also treated.

Shielding Effect in a System Due to Currents in Parallel Conductors; M. Krakowski (Tech. Univ., Lodz, Poland) - Arch. Elaktrotech. (Poland), Vol. 21, No. 1, p. 107-23 (1972) in English.

The active power in the conducting medium due to currents in a parallel multiconductor system is examined. The conducting medium possesses two layer structure; namely, a non-ferromagnetic shield is placed on the surface of the semi-infinite medium. The active power density on the surface of the shield is calculated for cylindrical and ribbon conductors. Furthermore, the total active power in the conducting medium is computed. The effect of shield thickness is examined. The considerations are based on idealized assumption that the permeability of the ferromagnetic medium is constant. It is shown, however, that the effect of variation in the permeability within wide ranges is very small.

Skin Effect in Shielded Straight Flat Conductors; A. L. Timotin, A. L. Nicolae (Polytech. Inst., Bucharest, Romania) - Revue Roam. Sci. Tech. Electrotech. & Energ. (Romania), Vol. 17, No. 1, p. 3-22, 1972, in English.

The influence of a perfectly conductive rectangular cross-section shield on the edge-effect in a straight flat conductor is presented. The distribution of the linear current density in the flatbar, the A.C. resistance, the reactance of the shielded bar, and the force density in the sides of the shield are determined using the magnetic vector potential. It is shown that the presence of the shield around the conductor reduces the edge effect in the bar, uniformizing the current density distribution.

Measurement of Grounding Device Spreading Resistance; M. I. Mikhailov, E. L. Portnov - Telecommunications and Radio Eng. Pt. 1, USA, Vol. 26, No. 2, p. 38-41 (Feb. 1972); Translation of: Elektrosvyaz (USSR), Vol. 25, No. 2, p. 51-5 (Feb. 1972).

The theory underlying the choice of distances between grounding devices and auxiliary electrodes when measuring grounding device spreading resistance by using the three electrode circuit is described. Curves for determining optimal electrode spacing when the electrodes and grounding devices are collinear are given. If the recommended electrode spacing is observed, the measurement error will not exceed ±2%.

Delta to Wye Conversion Technique Proves to be Economical; J. E. LaCrosse - Transm. and Distrib. (USA), Vol. 24, No. 3, p. 80-1 (March 1972).

Grounding the corner of delta distribution circuits during conversions to wye has resulted in substantial labor savings and in one case eliminated an estimated six-hour interruption.

Earthing High Voltage Substations - Elec. Times (GB), Vol. 161, No. 10, p. 35-6 (9 March 1972).

Methods of earthing substations above 100 KV are outlined and earth resistance measurement problems are discussed.

The Economics of Earthing and Consumer Protection - Elec.Rev. (GB), Vol. 190, No. 12, p. 400-1 (24 March 1972).

Controversial views on all-insulated wiring systems and protective multiple earthings are presented.

Digital Simulation and Analysis of Surges on Polyphase Transmission Lines with Earth Return; K. D. Tran, J. Robert (Laval Univ., Quebec, Canada) - IEEE Trans. Power App. & Syst., (USA), Vol. PAS-91, No. 2, pp. 445-51 (March-April 1972).

A method of analysis and a digital simulation of surges on polyphase EHV transmission lines with earth return are presented. The analysis allows mathematical calculations of switching surge wavefronts and gives a better insight into the distortions of the waves due to the earth-resistance. This digital simulation is easy and straightforward. It is based on the property "the more the groundmode propagates, the more its time delay increases." Simulated curves are found to be in good agreement with analytical results and with test oscillograms.

To Determine the Effect of Earthed Interphase Barriers on Electrical Equipment; K. D. Richards - Mining Technology (GB), Vol. 54, No. 618, p. 12-13 (April 1972).

This article describes tests to determine correlation between types of fault and level of destruction by short circuit.

Shielding 400KV Lines Against Direct Lightning Strokes; V.N. Rikh, (U.P. State Electricity Board, U. Karamaditya Merg, Lucknow, India) - Elec.Eng. (Australia), Vol. 49, No. 4, p. 33-4 (April 1972).

Points out that the behavior of lightning with reference to the transmission lines has been tested and investigated over the past few decades. As a result many approaches to ensure safe line design against direct lightning strokes have been suggested and sometimes subsequently modified. Out of these the one which has been most favored assumes that the lightning stroke of a given potential is attracted to an object which first comes within its attraction zone, the attraction distance increasing as the stroke potential is increased.

Overhead Shielding of Transmission Lines Improves Reliability; O. D. Ringness - Transm. & Distrib. (USA), Vol. 24, No. 4, p. 58-66 (April 1972).

Points out that while shielding may add 30% to the cost of line construction, the substantial benefits resulting justify this expense.

Earthing Practice Overseas; W. L. Leicester - Elec.Times (GB), Vol. 161, No. 16, p. 33-6 (20 April 1972).

The need to protect electricity users from shock hazard is the determining factor for a country's earthing philosophy and this philosophy must be an extension of the approach adopted by the electricity supply companies. For this reason the types of electricity supplies available must be considered.

Equipments for Incorporation Analysis in the Medical Department of the National Centre for Radiation Protection of the GDR; K. E. Poulheim (Nat. Centre Radiation Protection, Berlin, Germany) - 2nd European Congress on Radiation Protection; Health Phys. Probs. of Internal Contamination. Abstracts only, Budapest, Hungary, 3-5 May 1972 (Budapest, Hungary; Eotras Lorrand Physical Society 1972) p. 76.

For critical examination of incorporation in man besides the extensive medical valuation it is necessary to have the cooperation of various physical methods, and in some cases, chemical preparation of samples. Equipments will be presented for incorporation analysis which are available in the medical department. Technical parameters and details of the construction, especially for the whole body counters, are given. The difficulties will be pointed out in building a high sensitive whole body counter near large broadcasting stations or other high frequency trouble sources. The realized precautions of the RF-shielding, and some results from whole-body counter measurements, are given. The future program of measurements and developments is outlined.

Factors Affecting the Stability of Semiconducting Polyfin Shielding Systems; U. V. Cesana, I. J. Marwick, J. H. McNamara (Rome Cable Div. Cyprus Mines Corp., New York NY, USA) - IEEE Trans., Power App. & Syst., Vol. PAS-91, No. 3, p. 932-940 (May-June 1972).

In selecting extrudable semiconducting polyfins for use as conductor and insulation shields for high voltage power cables, too much emphasis is often placed on initial volume resistivity. An engineering analysis, covering the electrical, chemical and physical requirements for these shields, reveals that a different balance of properties is desirable for each application and that volume resistivity may be of secondary importance. This paper covers the results of an extensive library investigation to determine the effects of temperature, time, materials processing, solvents, and electrical tape adhesives of nine commercially available semiconducting materials, and five experimental variations, and offers a guide for selecting semiconducting compounds for optimum service performance.

The Effects of Arcing Ground Faults on Low-voltage System Design; J. R. Dunki-Jacobs (General Electric Co., Schenectady NY, USA) - IEEE Trans. Ind. Appl. (USA), Vol. IA-8, No. 3, p. 223-230 (May-June 1972).

The effects of arcing ground faults are discussed so that not only a greater appreciation can be gained from the elusive nature of this type of fault but also a better understanding of the requirements for applying protective devices. This knowledge is used to evaluate the degree of effectiveness of direct acting phase-overcurrent trip devices which leads into a discussion of the various ground fault protection modes. Subsequently the consequences of ground faults occuring on low voltage systems protected by fuses are discussed to highlight the adverse consequences of single phasing.

Changing Concepts and Equipment Applied on Grounded Low Voltage Systems; A. A. Regotti (Westinghouse Electric Corp., East Pittsburg PA (Usa) H. S. Robinson - IEEE Trans. Ind. Appl. (USA), Vol. IA-8, No. 3, p. 231-236 (May-June 1972).

Without firm assurances from the operating management for continued availability of skilled and experienced maintenance personnel, the authors favor the solidly grounded system utilizing sensitive protection devices for isolation of low-level and above-ground ground facilities.

A Note on Grounded Thermocouple Circuits; R. P. Benedict, R. J. Russo, (Westinghouse Electric Corp., Lester PA, USA) - Trans. ASME Ser. D (USA), Vol. 94, No. 2, p. 377-380 (June 1972).

Basic circuits involving the thermocouple as a temperature-sensing device have been described and analysed in the literature. However, relatively little has been written on the thermocouple as part of an overall instrument circuit wherein external electrical effects are important. After reviewing the more important electrical effects which are extraneous to the basic thermocouple circuit, the problem of multiple grounds in a thermocouple proper is considered in some detail. Experiment and analysis indicate that serious errors in temperature measurement can result from the use of improper grounds in thermocouple circuits.

Electromagnetic Shielded Connector; A. D. Bunch, R. F. Kantner - IBM Tech. Disclosure Bull. (USA), Vol. 15, No. 1, p. 34-35 (June 1972).

Describes a spring device for allowing continuous machine shielding where a gap has been made for connection by wires of external circuitry.

Creped Foil Cable Shield; A. D. Bunch, R. F. Kantner - IBM Tech. Disclosure Bull. (USA), Vol. 15, No. 1, p. 36 (June 1972).

Describes a cable in which shielding is provided by a creped paper tape with a conductive foil on the surface. A drain wire is also provided for easy termination.

Techniques for Protecting Brushless A.C. Generators; J. W. Hodgkiss, G. W. Mattews - Elec. Times (GB), Vol. 161, No. 23, p. 34-36 et seq., 8 June 1972.

A discussion of general considerations, earthing, and differential protection are covered.

Determining Peak Currents that Cause Ground Potential Rise; F. B. Hunt (New England Electric System, Westboro MA USA) - Proc. of the IEEE 1972 International Conference on Communications, Philadelphia PA, 19-21 June 1972 (New York USA: IEEE 1972), pp. 43-5/5.

The maximum possible ground current is determined for various power system impedances as a single phase to ground fault changes to a two phase to ground fault. The method of calculating the currents during the transient period is described and typical values are tabulated. These ground fault currents are needed to select protective equipment for communications circuits from the ground potential rise.

Tower Maintenance, or, The Bigger They Are - Communications (USA), p. 6-7 (July 1972).

Recommendations are made for initial and regular inspection and maintenance of tower guys, structural components, lighting, paint work, alignment, foundation, anchoring and earthing.

Lightning Protection for TI Carrier; A. H. Erlund (Vicom, Mountainview CA USA) - Telephone Eng. & Manage. (USA), Vol. 76, No. 16, p. 55-7 (15 August 1972).

The author discusses telephone line grounding problems and describes for properly grounding TI carrier system repeaters: totally grounded; floating repeater; and by-pass.

Grounding of Large Electrical Installations in Limited Area of High Earth Resistivity; S. N. Roy (U.P. State Electricity Board, Dehradun, India) - J. Inst. Engr. (India), Electr. Engr. Div., Vol. 52, Pt. EL-6, No. 12, p. 308-14 (August 1972).

Grounding of large electrical installations in limited areas of high earth resistivity poses special problems. Recommended low values of ground resistance are difficult to achieve for such cases. However, the installation can be made safe by limiting the potential gradients and by adopting special means. Design of a grounding mat and determination of step and touch potentials encountered involve lengthy claculations or a computer program by way of varying the depth of burial, spacing and number of parallel paths of the grounding conductor. With a few sets of calculations given in this paper, the length of conductor required to limit dangerous potential gradients is represented graphically with respect to the above variants giving the required information at a glance and making the designing processes simpler.

Progress Report on the Use of Aluminum Neutral Cable; B. E. Smith (Virginia Elec. & Power Co., Richmond USA) - Underground Eng. (USA), Vol. 3, No. 5, p. 13-15 (August-September 1972).

This paper expresses the Virginia Electric Co.'s concern about the availability and high cost of copper for utility application. Studies of alternate materials have resulted in the application of aluminum and other metals and plastics as a substitute for copper for such products as overhead wire, insulated conductors, grounding rods, transformer windings, bus bars and counterpoise installations.

Safety Considerations in Light Electrical Testing; R. W. Nettleton (Univ. Dayton, Ohio, USA) - SERT J. (GB), Vol. 6, No. 5, p. 101-3 (Sept. 1972).

The author describes four wiring systems for laboratories used for light electrical testing, and live chassis testing in particular. The relative safety of each system is discussed with reference to the effectiveness of fusing, electric shock protection, accidental contact with earth, and contact with other working positions. A system using an isolation transformer to the item under test with all other equipment on "raw" mains with an earth was preferred.

Earth Protection Circuit; Brown Boveri & Co., LTD. (Patent UK1280704 Sept. 2, 1969) pub. 5, July 1972, prior. 3 Sept. 1972, Czechoslovakia 13199.

Discloses an earth protection circuit for a three phase star connected alternator having a three phase transformer with a star connected primary and an open delta secondary. It has filters between the transformer secondary and a rectifier and between a single phase transformer secondary winding and a second rectifier, the relative magnitudes of the d.c. outputs of the rectifier being used to indicate an earth fault.

Electrical Noise in Machine Tool Controls; M. R. Swinehart (Cutler-Hammer, Inc., Milwaukee WI, USA) - IEEE Trans. Ind. Appl. (USA), Vol. IA-8, No. 5, p. 535-41 (Sept.-Oct. 1972)

The most troublesome electrical noise source in industrial control systems, the "showering arc," and the resulting induced noise in adjacent lines is characterized by ocillograms and other measurements. It is shown that shunt capacitance due to wiring can increase the severity of this noise. Transient voltage peaks of 1700V have been observed; 2000V peaks are common in 120V a.c. systems. Malfunctions of control systems due to these transients can be its source. A method of providing assistance in the selection of a capacitor quench circuit is presented, showing that capacitors of not more than 0.5 μf are adequate.

Earth Fault Test Apparatus (EFTA) - BBC Eng. (GB), No. 92, p. 34, Oct. 1972.

The apparatus avoids the need to open circuit the technical-earth cable and can remain in operation continuously. A toroidal core carrying several windings permanently surrounds the technical-earth cable. One winding is tuned to form a very high Q circuit resonating at 5KHz. The presence of the oscillation is monitored by a detector amplifier feeding appropriate alarm circuits. The technical-earth cable, passing through the toroidal core, acts as another winding and, when a fault exists between the sound equipment and any other earthed metal work, behaves as a short-circuited turn and severely damps the tuned-circuit. The oscillator is so designed that the decrease in Q of the tuned-circuit causes oscillation of output from the detector amplifier.

Medium Voltage Earthing Practice in Quarries; R. S. Rawling - Mining Technology (GB), Vol. 549, No. 624, p. 143-5 (Oct. 1972).

This article gives a theoretical background followed by a discussion on conductivity, rules and regulations and earthing continuity.

The Effect of Arcing Ground Faults on Low-Voltage System Design; J. R. Dunki-Jacobs (General Electric Co., Schenectady NY, USA) - Proc. of the 1972 Seventh Annual Meeting of the IEEE Industry Applications Society, Philadelphia PA USA, 9-12 Oct. 1972 (New York, USA: IEEE 1972), p. 161-70.

The author attempts to present a fundamental story on the subject of arcing-ground faults to the extent that not only a greater appreciation can be gained from the elusive nature of this type of fault but also a better understanding of the requirements for applying protective devices. This knowledge is used to evaluate the degree of effectiveness of direct-acting, phase overcurrent trip devices which leads into a discussion of the various ground fault protection modes. Subsequently the consequences of ground faults occurring on low voltage systems protected by fuses are discussed to highlight the adverse consequences of single phasing.

Effect of a Two Layer Earth on the Electric Field Near HVDC Ground Electrodes; T. N. Giao, M. P. Sarma (Hydro-Quebec Inst. Res. Varennes, Canada) - IEEE Trans. Power Appar. & Sys. (USA), Vol. PAS91, No. 6, p. 2356-65 (Nov.-Dec. 1972).

Analysis of the potential and field distribution in the vicinity of HVDC ground electrodes has until now been confined to the case of homogeneous earth. However, the case of an electrode buried in non-uniform earth is of greater practical interest. In most practical cases, the resistance variation of the earth may reasonably be characterised by a two-layer earth model, comprising a top layer of finite depth followed by a layer of different resistivity extending practically down to infinity. A method of analyzing the electric field in the vicinity of HVDC ground electrodes, buried in the top layer of a two-layer earth model is presented in this paper. The method is applied to several practical electrode configurations to determine the current distribution along the electrode-soil boundary as well as the potential and field distribution in the vicinity. A method of normalization is suggested and all the results are presented in the normalized form.

New Data Acquired in the Realm of Practical Short-Circuit Tests on Experimental Earthing and Shorting Devices; F. Schoffel (Central Electricity Supply Co., Vienna, Austria) - 2nd International Colloquium of the International Section of the ISSA for the Prevention of Occupational Risks due to Electricity (Cologne, Germany, 30 Nov.-1 Dec. 1972)(Geneva, Switzerland: International Social Security Assoc. 1972), p. 89-91.

The above includes summaries of the reports given.

Ground Connector for Conduit: A. R. Norden, Oz Electrical Mfg. Co., Inc., patent USA 3706959, 8 April 1971 - published 19 Dec. 1972, US 132462.

A grounding device is disclosed wherein a bushing is adapted to be threaded onto an end of conduit extending through a wall of a housing and a grounding lug is secured on the periphery of the bushing. The lug has a resilient C-shaped wire clamping portion and resilient wings extending from opposite ends thereof formed so as to provide spring tensioned connections to the periphery of the bushing. The wings have teeth adapted to make grounding connections with the wall of an enclosure or box upon threading of the bushing onto conduit extending through the enclosure, additionally providing anti-turning means to prevent the lug from rotating on its mounting screw.

Screening Effect of Power Cable Armour and Sheath; B. P. Golosnov, V. V. Platonov (Novocherkass Polytech. Inst., USSR) - Electrical Technology USSR (GB), No. 3, p. 40-8 (1973). Translation of: Selected articles from Elektrichestro (USSR), p. 78-80 of No 7 (1973).

Reports results of a test analysis for low frequencies. A screening factor is derived which decreases with increasing frequency and is independent of the core cross section. This contributes to an induction method of interphase fault location, having regard to Pb and AL sheaths.

Electromechanical Aspects of Radio Interference Suppression and Systems Earthing Methods; C. J. Richards - In book: Electronic display and data systems: constructional practice, p. 409-48. Maidenhead, Berks, England: McGraw-Hill (1973).

This section deals with noise sources of a non-random nature and attempts to outline established practical methods for reducing such noise in circuits associated with the transmission, reception, and processing of electromagnetic energy.

Electromagnetic Induction in Conductive Shells; J. R. Wait (Univ. of Colorado, Boulder, USA) - Canadian Journal of Physics (Canada), Vol. 51, No. 2, pp. 209-218, Jan. 15, 1973.

The shielding characteristics of thin conductive shells are considered Both elliptical and spheroidal shapes are treated using a thin-sheet boundary condition. It is shown that the form of the solutions is relatively simple if the angular variation of the shell thickness is taken to vary in a prescribed fashion. In such cases, the internal field is reduced by a factor $(1+j\omega\tau)^{-1}$ relative to the external primary field where ω is the angular frequency and τ is a response factor that depends on the shell dimensions. The results for cylindrical and spherical shells are obtained as special cases.

Electrical Power Systems Neutral Grounding Practice to Minimize Downtime; K. J. Owen - 59th annual meeting 1973 of the Technical Section of the Canadian Pulp and Paper Assoc., Montreal Canada, 23-26 January 1973 (Montreal, Canada: Canadian Pulp & Paper Assoc., 1973) pp. 1-8.

The philosophies used in the past to determine the merits of operating power systems in a grounded or ungrounded neutral mode are considered no longer completely valid, due to the advent in recent years of monitoring devices, highly sensitive to very small deviations in normal phase-ground conditions. It is the intent then to review these philosophies and propose a particular approach--namely high resistance grounds to the function of the neutral that retains the advantages and reduces the disadvantages of past power system operation, still leaving the operator of the power system the option of selecting the mode of operation; that is, to trip or annunciate only when phase-ground relationship becomes abnormal. It is also proposed that this concept will minimize both the rate of and elapsed down times.

Neutral Grounding and the Prevention of Neutral Instability; [illegible]. B. Johnson, J. R. Stevenson (General Electric Co., Schenectady, NY, USA) - IEEE Transactions Power Apparatus and Systems (USA), Vol. PAS-92, No. 1, pp. 341-345 (Jan.-Feb. 1973).

Investigative results from a systems-in-miniature setup are presented concerning the stability of Y-connected potential transformers, and the effect of potential transformers as generator neutral grounding devices. Included is the influence of a resistance burden on the neutral grounding transformer.

A Method for Producing Long, Cylindrical, Super Conducting Flux Shields; A. C. Newton, F. Martin, S. J. St. Lorent, W. T. Toner (Stanford Univ., Calif., USA) - Rev. Sci. Instrum. (USA), Vol. 44, No. 2, p. 244-245 (Feb. 1973)

A technique is described for making long, cylindrical, magnetic flux shields from Nb_3Sn superconducting tape.

Ground-fault Protection of a 15 KV Cable System; A. Wendorft (Zakland-Energetyczny, Krakow-Hiosto, Poland) - Enegetyka (Poland), Vol. 27, No. 3, pp. 89-90 (March 1973).

The results of the protection functioning in a part of the Krakow 15KV cable system is discussed. Due to an expansion and modernization this part of the cable system has been equipped with a ground-fault tripping protection and with an automatic emergency feed closing.

A Review of Lightning Protection and Grounding Practices; G. W. Walsh (General Electric Co., Schenectady NY, USA) - IEEE Trans. Ind. Appl. (USA), Vol. IA-9, No. 2, pp. 133-148 (March-April 1973).

Guides are presented to facilitate proper economic lightning protection of industrial power system component arrangements. Basic concepts of the traveling wave nature of lightning are included to enhance under-standing of protective practices as they have developed and emphasizing the need for careful adherence to approved practices in critical areas. The grounding treatment is very brief, being limited to the most salient considerations of equipment grounding in relation to the over-all lightning protective system and the ground fault protective system. The paper is referenced throughout to current industry standards, application guides, and codes.

Trends and Practices in Grounding and Fault Protection Using Static Devices; R. O. D. Whitt (Westinghouse Corp., Beaver, Pa., USA) - IEEE Trans. Ind. Appl (USA), Vol. IA-9, No. 2, pp. 149-157 (March-April 1973).

Grounded and ungrounded systems are in general use in both commercial and industrial distribution systems. This paper briefly identifies the types of systems in use in each category and lists some of the main advantages and disadvantages of each. The need for adequate protection has been recognized by the 1971 Electrical Code (national). This recognition is being complemented by Underwriters Laboratories with the introduction of appropriate standards. With the passing of the Occupational Safety and Health Act of 1970, more emphasis than ever before will be placed on adherence to the preceding code and standards. This paper reviews the various methods of detecting ground faults using static devices and describes some of the equipment available for these applications.

Pulse Shielding by Nonferrous and Ferromagnetic Materials, F. J. Young (Westinghouse Research Labs., Pittsburg PA (USA) - Proc. IEEE (USA), Vol. 61, No. 4, pp. 404-413 (April 1973).

The problems encountered in pulse shielding by ferromagnetic materials are discussed. A limiting nonlinear shielding theory for magnetic materials based on the classic switching theory of ferromagnetism is established and verified experimentally. The limiting nonlinear theory includes the influence of saturation induction, coercive force, electrical conductivity, and pulse charge. The pulse shielding effectiveness of many types of shielding materials, both ferrous and nonferrous, is analyzed. The material costs and weights are compared. It is shown that below a certain pulse level (current), nickel-iron alloys produce the lightest shields. Above that current level, nonferrous materials become lighter because they are less dense. Suggestions for the improvement of ferrous alloys are included.

Magnetic Shielding for Magnetically Leviated Vehicles: Y. Iwasa (MIT, Cambridge MA, USA) - Proc. IEEE (USA) Vol. 61, No. 5, pp. 5[illegible]-6[illegible]3 (May 1973).

Shielding is needed to protect passengers in a vehicle from stray d.c. magnetic fields coming from the superconducting dipoles carried in the vehicle. In addition, the superconducting dipoles must be shielded against various a.c. magnetic fields. The author considers shielding of a.c. magnetic fields generated by the propulsion windings for the case of a linear-synchronous motor active guideway.

<u>Problems with Large Ground Fault Currents in Utility Substations in or near Industrial Sites</u>; L. C. Peterson (H. A. Simons International Ltd., Vancover, British Columbia, Canada) - IEEE 1973 Annual Pulp and Paper Industry Technical Conference, Jacksonville FL, 1-4 May 1973 (NY, USA: IEEE 1973), pp. 35-41.

One of the prime functions of equipment grounding is for safety to life and property. In designing an industrial power system that obtains any energy from a utility with a high ground fault current capability, it may be advisable to isolate the industrial and utility ground grids for safety reasons. A review of present practices as well as suggested modifications with an actual design example is presented.

<u>Influence of Third Harmonic Circulating Currents in Selecting Neutral Grounding Devices</u>; L. J. Powell, Jr., General Electric Co., Schenectady, NY - IEEE 1973 Annual Pulp and Paper Industry Technical Conference, Jacksonville FL, 1-4 May 1973 (New York, USA: IEEE 1973), pp. 24-32.

It has long been recognized that third harmonic currents can and often do appear in the neutral of mill generators.

This paper reviews the causes of such currents and the effect these currents can have in the paper mill power system. The common methods of neutral grounding will be discussed with regard to circulating harmonic currents.

<u>Hazards During Ground Faults on 480 Volt Systems</u>; R. A. Harvey - 1973 Industrial and Commercial Power Systems Technical Conference, Atlanta GA, USA, 13-16 May 1973 (New York, USA: IEEE 1973), pp. 64-[illegible]

It is known that arcing ground faults on 480 volt systems are often too small to actuate phase protective devices. GFI's have been introduced to ensure clearance of such faults. They are costly when used in quantity, and are mandatory only on large capacity circuits. Their use will, therefore, be limited. The hazard of exposure voltages which are not removed by phase protective devices, therefore, remains of great concern. The magnitude of exposure voltage on several common wiring systems is explored and the relative safety evaluated. Different systems produce exposure voltages with maximums ranging from 4[illegible] to [illegible]90 volts. Means are presented for reducing the exposure voltage on those systems which are most hazardous.

An Impulse Voltage Divider Covered with Metal Cylinder and Improvement of Its Response Characteristics; T. Kuono, S. Kato (Univ. of Tokyo, Japan - Elect. Engr. Jap. (USA), Vol. 93, No. 3, pp. 49-55 (May-June 1973). Translation of: Trans. Inst. Elect. Engr. Jap. (Japan), Vol. 93, No. 3(May-June 1973). Received: Nov. 1974.

Most impulse voltage dividers used at present are shielded from electromagnetic radiation interference by grounded metal cylindrical covers. However, the stray capacitances between voltage-dividing resistances and the metal shield cover worsen the response characteristics. A method is proposed to improve the response characteristics in which the input voltage is picked up by using a small capacitance voltage divider and applied to a shaping filter. The output voltage of this filter is then superimposed on the output voltage of another voltage divider.

Determination of Induced Currents and Voltages in Earth Wires During Faults; L. Y. M. Yu - Proc. Inst. Elect. Engr. (GB), Vol. 120, No. 6, pp. 689-692 (June 1973).

The multiconductor analysis introduced to the study of the current and voltage distributions of power transmission lines of any configuration may account for the induced currents and voltages in earth wires at any point of interest along a transmission line under fault or normal conditions at any operating voltage levels. The earth wires are employed as individual entities in the analysis along with the line conductors in extra-high-voltage transmission lines of power frequency. From the safety and reliability point of view, the prediction of induced currents and voltages in earth wires under the fault conditions of the line conductors is significant and important for those power transmission lines operated at high-voltage or extra-high-voltage levels.

Use of Magnetic Materials for Improvement of Screening Properties of Different Types of Cables; L. Halme, J. Annanpalo (General Direction Posts and Telegraphs, Helsinki, Finland) - 1973 IEEE International Electromagnetic Compatibility Symposium Record, New York USA, 20-22 June 1973 (New York: IEEE 1973), pp. 340-357.

The theory of interference voltages coupling through the transfer impedance into coaxial cables having single, double, and triple outer conductors and the use of magnetic materials between the outer conductors is presented. Measured transfer impedances of different cable types are shown. Further, the crosstalk attenuation between electrically short coaxial cables is derived and measured crosstalk attenuations are presented for different coaxial cable types. The measurements were carried out up to 80MHz, and the measuring limit was 180 db of crosstalk attenuation. The use of magnetic material improves the screening efficiency considerably in the frequency range 10KHz...10MHz. The use of a conducting layer and a high permeability tape in shielding of balances pairs is treated and results of crosstalk attenuation measurements are shown. Finally, the screening performance of magnetic shielded coaxial cables under heavy interfering currents is treated. Measurement results are shown of tests made with a current pulse of 20...460 amp. peak value flowing in the outer conductor.

Adequate Margins for H.V. Line Lightning Protection; B. N. Rikh - Electrical Engineering (Australia), Vol. 50, No. 7, pp. 26-28 (July 1973).

A method of determining shielding angles associated with various ground wire heights to give adequate margins against direct lightning strikes in high-voltage transmission lines is described.

Utility Grounding Practices; H. M. Smith, General Electric Cablevision Corp., San Antonio TX, USA - Cablecasting-Cable TV Engr., Vol. 9, No. 2, pp. 6-10, July-Aug. 1973.

This article discusses the principles and safety regulations of earthing techniques. The author describes the optimum methods and some of the problems involved.

Study of Relative Effectiveness of Conduits and Grounding Conductors in Reducing Potential Differences in a Patient's Room Produced by Fault Currents; G. N. Webb, D. Gordon (Johns Hopkins Hospital, Baltimore, Maryland) - Proceedings of the 26th Annual Conference on Engineering in Medicine and Biology, Minneapolis, Minn., USA, 30 Sept.-4 Oct. 1973 (Arlington VA, USA: Alliance for Engineering in Medicine and Biology 1973), pp. 241.

In the interests of patient safety an understanding of the function of power conductors, conduits and parallel conductive paths inside and outside the conduit, during fault conditions is important in assessing grounding procedures and estimating potential differences in the patient vicinity. More references on this subject deal with massive fault currents on major feeders and do not consider the potentials that may develop in a patient room when fault currents do occur which do not operate current limiting devices.

Impulse Characteristics of Horizontally-buried Straight Conductors used as Grounding Electrode; B. Thapar, R. P. Nagar (Punjab Engr. College, Chandigarh, India) - J. Inst. Engr. (India) Elec. Engr. Div., Vol. 54, Pt. EL1, pp. 11-15 (Oct. 1973).

To predict the impulse behavior of grounding electrodes, it is necessary to evaluate the effect of the various factors controlling the impulse characteristics. In this paper an analytical method is developed to determine the effect of those factors and to evaluate the impulse grounding impedance of a single horizontal conductor subjected to impulse currents. It is shown that the impulse grounding impedance of a straight horizontal electrode does not change if the length of the conductor is increased beyond its effective length, which depends upon the resistivity of the soil and the time-to-peak of the applied impulse current. An equivalent lumped π network is defined to represent the single horizontal grounding conductor.

A Review of Lightning Protection and Grounding Practice; G. W. Walsh (General Electric Co., Schenectady NY) - 1973 8th Annual Meeting of the IEEE Industry Applications Society, Milwaukee, Wisconsin, 8-11 October 1973 (New York, USA: IEEE 1973), pp. 465-480.

Guides are presented to facilitate proper economic lightning protection of industrial power system component arrangements. Basic concepts of the traveling wave nature of lightning are included to enhance understanding of protective practices as they have developed and emphasize the need for careful adherence to approved practices in critical areas. The grounding treatment is very brief, being limited to the most salient considerations of equipment grounding in relation to the overall lightning protective system and the ground fault protective system. The paper is referenced throughout to current industry standards, application guides, and codes.

Computer Aided Magnetic Field Calculations for Nonlinear Shielding Materials; D. B. Goodrich, J. S. Warford Aerospace Div. of Honeywell, St. Petersburg FL - IEEE Trans. Magn. (USA), Vol. Mag-9, No. 3, pp. 261-265, Sept. 1973.

This article describes a general computer program, developed to calculate magnetic fields in the presence of ferromagnetic shields by solving the two-dimensional Laplace equation on a rectangular grid of up to 5,000 nodes using the difference-equation technique. It may assume the magnetic induction $\vec{B}$ to be either a linear or nonlinear function of the field strength $\vec{H}$. Shielding material thickness for most applications is small compared to the difference equation grid resolution. Therefore, a resistor network analogy was used to appropriately modify the difference equation for thin materials on a uniform grid.

Modelling of Potential Distribution Around a Grounding Electrode; D. Mukhedkar, Y. Gervais, F. Dawalibi, Ecole Polytech., Montreal, Canada - IEEE Trans. Power Apparatus and Systems, Vol. PAS-92, No. 5, pp. 1455-1459, Sept.-Oct. 1973.

A twin layer model is used for experimental determination of the potential distribution around and near different ground electrodes. An attempt is made to study the effect of local top layer discontinuities on potential distribution in a twin layer model.

Surface Transfer Impedance Measurements on Submarine Coaxial Cables; C. N. McDowell, M. J. Bernstein (Aerospace Corp., El Segundo CA, USA) - IEEE Transactions Electromagnetic Compatability (USA) - IEEE Trans. Electromagnetic Compatability (USA), Vol. EMC-15, No. 4, pp. 188-190 (Nov. 1973).

The surface transfer impedances (STI) of several flexible subminiature coaxial cables, such as RG-174/U and RG-188/U, plus smaller coaxial shielded wires, were measured to determine E.M. shielding characteristics. The results cover the frequency range 0.1-50MHz and correlate well with previous theoretical models and with experimental values for larger cables, such as RG-58. Copper-braided subminiature cables had STI values 2-5 times larger than those for RG-58.

Sneak Ground Currents in A-C Power Systems; L. Yenraque - Electrical Construction and Maintenance, Vol. 72, No. 11, pp. 80 (Nov. 1973).

Sneak currents in A.C. power systems are those currents that flow in the grounding conductor for no apparent reason. Regardless of the size of the system, ground currents will be present to some extent, whether measureable or not, contributing to malfunctioning of sensitive equipment and nuisance tripping of ground fault protective devices. In this paper suggestions of possible methods to aid attenuation and control these ground currents are given.

Electromagnetic Shielding as Applied to Defense Communications; A. P. Hale (Belling and Lee Ltd., Enfield, England) - Communications 74, Brighton, Sussex, England, 4-7 June 1974 (London, England: IPC Business Press 1974), pp. 11-3/1-9.

The requirements for electromagnetic shielding fall into three primary categories. Firstly, the establishment of a "quiet zone" for the alignment repair and measurement of sensitive equipment is needed where the presence of ambient radio signals would complicate and confuse the work in hand. The second requirement is the protection of operational communications equipment such as computers and similar digital equipment against the effects of high power signal sources, such as radar installations, which would otherwise cause malfunctioning of the protected equipment, the third case where shielding is normally employed is in the security field where it is frequently deemed advisable to protect computer installations, conference rooms, etc., against the possibility of eavesdropping.

Transient Forces in Individually Screened Three Phase Conductor Systems; C. Ionesch (Polytech. Inst. Bucharest, Romania) - Rev. Roum. Sci. Tech. Ser. Electrotech. and Energ., Vol. 19, No. 3, pp. 397-427 (1974)

A method is suggested for the study of the transient operating conditions in systems of conductors, individually screened by thin, imperfectly conducting, circular cylindrical screens. The solving by the known methods of the equations of electromagnetic fields, leads to solutions to determine the magnetic field induction and the electromagnetic forces in the transient operating conditions, corresponding to various types of injuries. The conclusions experimentally verified, are that the advantage of a nearly perfect screening of phases that appears in the steadystate operating conditions in the case of such a screening, is equally maintained in transient operating conditions.

Induced Currents in Electrically Coupled Screens of Charge Conductors; V. F. Laslo, Yu G. Samoilov, G. N. Tsitsikyan - Electr. Technol. USSR (GB), No. 1, pp. 99-107 (1974). Translation of selected articles from Elektrichestro (USSR), pp. 89-91 of No. 2 (1974).

Proposes a method for evaluating contour currents induced in electrically coupled screens of conductors which are screened phase to phase. An estimate of compensation is made to offset overheating at very large power stations.

On Allowing for the "Longitudinal" Impedance of Horizontal Elements in Large Earthings; A. I. Yakobs, P. I. Petrov (All-Union Agricultural Electrification Res. Inst., USSR) - Electr. Technol, USSR (GB), No. 1, pp. 9-22 (1974). Translation of: Selected articles from Elektrichestro (USSR), pp. 13-18 of No. 1 (1974).

The use of extra high voltage (500KV or more) for power transmission has led to considerable changes in some of the parameters of transformer substations (surface area, earth fault current, etc.) which have a great influence on earthing design. Widespread use is now made of reinforced-concrete structures which can be used as natural earthings. A limit is found to the equipotential assumption in the analysis of complex earthing grids. It is shown that the induced potential algorithm can lead to 50% error or more. A new model is proposed which allows for distributed parameters on horizontal elements in calculating electric characteristics of complex earthings.

Using the Structure's Reinforcing Steel as an Electrical Earth; P. G. Wright (Min. Works, Auckland, New Zealand) - New Zealand Eng. (New Zealand), Vol. 29, No. 1, pp. 15-20 (15 January 1974).

This paper summarizes the earthing requirements for electrical and lightning protection purposes and describes the still little known method, as titled, which consistently achieves better results than conventional methods. It details the application to a major building complex, compares theoretical and measured results, and relates aspects applicable to prestressing steels. It recommends that this method be published and incorporated into the Electrical Wiring Regulations as an optional approved method.

Ground Electrode Resistance Measurements in Non-uniform Soils; F. Dawalibi, D. Mukhedkar (Shawinigan Engng. Co. Ltd., Montreal, Quebec, Canada) - IEEE Transactions Power Apparatus and Systems (USA), Vol. PAS-93, No. 1, pp. 109-115 (Jan.-Feb. 1974).

Ground electrode resistance measurements are usually done by fall of potential method. The potential probe position (0.618 rule) has been calculated for homogeneous soil. Theoretical computation and experimental verification of the potential probe position in non-homogeneous soil is presented. The experimental work was carried out on a twin layer laboratory model.

Identification of Electrical Parameters in Large Earth Grids; R. M. Huey, K. Rajaratnam (Elektrotechnik, Aachen, Germany) - IEEE Trans. Power Apparatus and Systems (USA), Vol. PAS-93, No. 1, pp. 187-195 (Jan.-Feb. 1974).

The conductors in the earthgrid of a large electric power station must withstand for the maximum fault duration, current due to the worst case unbalanced fault. The fault duration and the worst case fault current may be calculated by well-known means. However, the division of fault current when it is injected into the earth grid is difficult to determine with confidence. The authors describe a scale modeling experimental technique which can yield improved data on the division of fault return current within an earth grid.

Measuring Connector Shielding Effectiveness During Vibration; E. D. Knowles, J. C. Brassier (Boeing Co., Seattle WA, USA) - IEEE Trans. Electromagnetic Compatability (USA), Vol. EMC-16, No. 1, pp. 24-29, (Feb. 1974).

This paper describes the equipment and technique used to measure shielding effectiveness of threaded electrical connectors during vibration. The vibration fixture is a modified coaxial trough of which the connector is a part. The connector is mechanically loaded with a short section of cable. A known current is applied on the shield of this short cable section and across the receptacle/plus interfaces. R-f leakage into the interior of the cable is determined by forming the interior wiring of the cable into a closed loop and measuring the current in this loop. The logarithmic ratio of the current in the shield to the current in the interior loop is the shielding effectiveness of the cable-connector combination. The cable shield is composed of brass convolute with a braid covering and provided by itself, 100 dB isolation. This isolation was demonstrated by testing the shielding effectiveness (S.E.) of a base line specimen which substituted a brass fitting for the connector. It is demonstrated that this method of testing connectors can be used to determine S.E. under vibration. The method is proposed as a standard method of qualification testing of connectors.

Cables Shielding Effectiveness Testing; E. D. Knowles, L. W. Olson (Boeing Co., Seattle WA, USA) - IEEE Trans. Electromagnetic Compatability (USA), Vol. EMC-16, No. 1, pp. 16-23 (Feb. 1974).

This paper discusses an improved method of measuring the effectiveness of cable shielding and describes the results of tests on single and multi-branched cables. Effects of effective shielding parameters are also reported. These are the effect of number of shield braid layers, braid material, braid angle, optical coverage, cable length, and wire size. The test method permits measurement of long specimens using high currents with a uniform current distribution along the cable shield. Measurements were made in the frequency range 0.5 to 100 MHz. The method is offered as a standard technique for measuring the shielding effectiveness of shielded cables.

Anti-corona Shields for UHV Applications; P. B. Barber, E. M. Dembinski, R. C. Hughes (CEGB, Leatherhead, England) - CEGB Technical Disclosure Bulletin (GB), No. 226, pp. 1-2 (March 1974).

The invention concerns the use of lightweight shields, toroidal in shape, made basically of reinforced polymeric resin and metal sprayed, the object being to prevent corona discharges on equipment operating at ultra high voltage.

Normal and Short Circuit Operating Characteristics of Metallic Shielding Solid Dielectric Power Cable; M. A. Martin, Georgia Power Co., Atlanta GA, USA - IEEE Trans. Power Apparatus & Systems, Vol. PAS-93, No. 2, pp. 601-613, March-April 1974.

This article includes test data on thermal runs of single conductor shielded power cable under typical installation conditions which confirm published ampacity data, and hence the theoretical procedure employed for calculating the ampacity of single conductor cable with circulating current losses. Simulated fault tests conducted in the field at typically high currents and with circuit breaker reclosures provide data on the performance of various types shields on solid dielectric power cable under line to ground fault conditions. The fault current capability of various type metallic shields has been determined by laboratory tests. Laboratory test data on a new design metallic shield, type LC, are presented.

Grounding for Industrial and Commercial Distribution Systems; A. A. Regotti, H. W. Wargo (Westinghouse Electric Corp., Pittsburg PA, USA) - Westinghouse Eng. (USA), Vol. 34, No. 2, pp. 41-45 (April 1974).

Phase to ground faults are the most common kind in distribution systems. Therefore, the kind of system grounding used (if any) and the ground-fault protection applied are important. They should be carefully chosen to fit the particular application.

Cable Reel Speeds Truck Grounding, Increases Safety; S. B. Torrence (Upper Cumberland Membership Corp., Carthage TN, USA) - Electrical World (USA), Vol. 181, No. 7, pp. 90-91 (1 April 1974).

A reel for speeding up the handling of grounding cable that is required for safety grounding of a construction vehicle has been developed through the coordinated efforts of the Upper Cumberland Electric Membership Corp., Carthage TN, and Kearney International, Inc., Chicago, Ill. The reel simplifies the grounding assignment, and thus encourages compliance by crew members with all OSHA rules. The grounding reel reduces the time required to set up safety grounding conditions at each work location. It eliminates labor and material costs formerly required for frequent replacement of grounding cables that were damaged when they were laid randomly across the mud and rock of the work site. Also it saves as much as an hour a day for a crew, and therefore will save its original cost in a short time.

Ground Shielded Current and Potential Transformers That Answer the Need for Underground-primary Metering Applications; R. J. Quellette (General Electric Co., Somersworth NH, USA) - 1974 Underground Transmission and Distribution Conference, Dallas TX, USA, 1-5 April 1974 (New York, USA: IEEE 1974), pp. 375- 77.

As the industry's need for primary metering of underground services develops, a need is emerging for ground-shielded dry-type metering transformers designed for padmounting in an enclosure as individual components with the capability of mating with loadbreak and non-loadbreak cable terminations.

An Earth Fault Monitor for "Floating" Control Systems; W. Meier (Siemens A G, Erlange, Germany) - Siemens Rev. (Germany), Vol. 41, No. 5, pp. 233-236 (May 1974).

Floating systems are becoming more and more popular in the electronic control field. However. such systems cannot operate reliably unless an earth fault monitor is installed to monitor them for earth faults and if necessary, give immediate warning of such faults. The earth fault monitor EA-2 operates on the principle of differential current measurement. The monitor, which is connected to earth via a high resistance, sends out a pulsating search current, which produces a voltage drop across a resistor, the magnitude of the voltage drop varying with the magnitude of the earth-fault resistance.

Equipment Grounding for Reliable Ground Fault Protection in Electrical Systems Below 600 Volts; R. B. West (Monsanto Co., St. Louis MO, USA) - 1973 Industrial and Commercial Power Systems Technical Conference, Atlanta GA, USA, 13-16 May 1973), pp. 48-63.

Equipment grounding is one of the most important, but least understood, requirements for reliable ground fault protection. This paper defines the basic objectives of equipment grounding and analyzes the role of equipment grounding conductors in providing ground fault protection for electrical systems below 600 volts.

A Superior Shielding System for Solid Dielectric Power Cables; U. V. Cesana, J. H. McNamara, I. J. Marwick (Cyprus Mines Corp., Rome NY, USA) - 1974 Underground Transmission and Distribution Conference, Dallas TX, USA, 1-5 April 1974 (New York, USA: IEEE 1974), pp. 490-498.

A performance analysis compares the relative merits of extruded semiconducting insulation shielding layers and thin semiconducting coatings, for characteristics such as stability under cyclic current loading, flexibility and handling, temperature coefficients of resistivity, thermal aging, moisture resistance and conformance with the insulation surface. Thus a value analysis of the power cables covered in this paper and their installation requirements clearly favors the thin polymeric semiconducting coatings. Methods of manufacture, material properties and components, procedures for splicing and terminating and cable design criteria are also described in this paper.

The Role of Premolded Connector Shield in the Cable System Shielding Circuit; R. J. Provencal (Amerace Corp., Hackettstown NJ, USA) - 1974 Underground Transmission and Distribution Conference, Dallas TX, USA, 1-5 April 1974 (New York, USA: IEEE 1974), pp. 241-246.

The reason for the cable shielding circuit problems followed by a review of the properties of cable shields and premolded connector shields will be the primary concern of this paper. Suggested methods of selecting cable shields and interconnecting shield to premolded connector shields, other cable shields, and grounding electrodes are presented. Finally, case histories of systems in which cable shielding circuits were improperly designed are included.

Earthing System Devices - Electrical Equipment (GB), Vol. 13, No. 6, pp. 30-31, 33, 35 (June 1974).

Since at some time or other most electrical installations will suffer, at least occasionally, from leakage currents, lightning strikes, static buildup or short circuits these abnormal conditions have to be catered for. This means that most systems have to have an effective and reliable earthing arrangement. Indeed it does not take long, reading accident investigation reports, to discover that the omission or failure of an earthing system can and has resulted in loss of supply for some lengthy periods, fire and subsequent equipment damage and even loss of life. Several devices for making earthing systems including the thermoweld electrical connection process are discussed.

FM Response of Shielded Cables: Numerical and Experimental Results; H. S. Cabayan, G. O. Fitzpatrick, M. L. Robonson (Intelcom. Rad. Tech., San Diego CA, USA) - 1974 International IEEE/AP-S Symposium Digest, Atlanta GA, USA, 10-12 June 1974 (New York, USA: IEEE 1974), pp. 354-356.

The results reported are for a braid-shielded coaxial cable with a single core conductor. The extension to a multi-conductor cable follows essentially the same procedure. A transmission line model is used to determine the currents on the surface of the exterior shield due to the external field excitation. The cable shield is assumed to be a solid cylinder above a perfectly conducting ground; it is loaded arbitrarily at both ends. The average electric and magnetic intensities at the outer surface of the cable shield can then be determined. The penetration of the electric and magnetic fields is described by means of capacitive and inductive coupling parameters, respectively. Once the distribution of excitation sources across the length of the interior of the cable is known, interior currents can be determined for arbitrary end loadings.

Shielding and Grounding Control Cables; W. C. Kotheimer (General Electric Co., Schenectady NY, USA) - Transm. & Distrib. (USA), Vol. 26, No. 7, pp. 52-55 (July 1974).

Two general sources for surges, aside from lightning, found in control circuits of switching stations are considered: switching phenomena on the high voltage system and switching on any of the low voltage systems in the station, including the control system itself. The subject of cable shielding is concerned chiefly with protection from surges outside the control circuit, the most severe being those originating on the high voltage system.

Groundfault Protection and Detection for Industrial and Commercial Distribution Systems; A. A. Regotti, H. W. Wargo (Westinghouse Electric Corp., East Pittsburg PA, USA) - Westinghouse Engr. (USA), Vol. 34, No. 3, pp. 80-83 (July 1974).

Deals with the characteristics of grounded and ungrounded distribution systems when phase-to-ground faults occur. Since those are the most common faults in distribution systems, they should have a major role (along with economic considerations) in determining the kind and amount of fault protection equipment to include in a system.

An Accurate Assessment of the Capacitances Characterising the Shielded Resistance Voltage Divider; A. W. Palmer, City University, London, England - C PEM 74 Digest: Conference on Precision Electromagnetic Measurements, London, England, 1-5 July 1974 (London, England: IEE 1974), pp. 176-178.

This paper considers the assumptions that have been made and introduces a new method for theoretically determining the response of the shielded divider. This is based on a more complete description of the stray electric fields associated with the divider. An appreciation of these stray electric fields, and of the method of describing them, is necessary in attempting to optimize the shield shape to gain higher accuracy resistive dividers for measuring time varying high voltages.

Earthproving for Portable Plant; A. Wright (A. Reyrolle & Co. Ltd., Hebburn, England) - Elect. Times (GB), No. 4291, p. 12 (25 July 1974).

Examines the main requirements of protection of portable and transportable equipment and illustrates how, typically, it is achieved in practice. A typical earth proving unit connected to a portable appliance which monitors impedance of the earth loop and disconnects the appliance should this impedance exceed a pre-determined value is described. It also rapidly disconnects the appliance should an earth fault appear. Main advantage of this protection is, that it does not depend upon sensing current flowing through an operator in contact with the appliance.

Analysis of Operation of a Transformer with Electrostatic Shielding; T. Toshima, I. Nishi - Rev. Electr. Commun. Lab. (Japan), Vol. 22, No. 7-8, pp. 663-673 (July-August 1974).

Operational characteristics of a transformer with arbitrary winding ratio and electrostatic shielding are analysed by introducing the parallel multi-wire model and applying the distributed constant theory. From calculated results, it is clarified that the real part of the input impedance characteristics can be adjusted by modifying the secondary winding structure and the imaginary part can be adjusted by modifying the primary structure. By using this input impedance adjusting method, it is possible to build practical shielded transformers that operate quite satisfactorily over a wide frequency range. The experimental data are closely coincident with calculated results.

Current Comparators with Superconducting Shields; K. Grohmann, H. D. Hahlbohm, H. Lubbig, H. Ramin (Berlin Inst. Phys.-Tech., Bundesanstalt, Germany) - Cyrogenics (GB), Vol. 14, No. 9, pp. 499-502 (Sept. 1974).

It is shown that the iron cores of conventional current comparators may be replaced by superconducting shields. Their function is to transmit the magnetic field of the exciting ratio windings regardless of their position and shape to a detector winding. A toroidal shield system with two modifications, a nested one and a helical one, has been combined with a SQUID to build up current comparators for d.c. and a.c. applications. The smallest d.c. error was found to be 5×10^{-10}. Finally, a practical example is given of the application of high precision cyrogenic current comparators.

Guarded Double Insulation--A Technique for Reducing the Shock Hazard of Grounded Electrical Systems; N. L. Kusters, M. P. MacMartin (Nat. Res. Council Canada, Ottawa, Ontario) - Fifth Canadian Medical and Biological Engineering Conference--Digest of papers, Montreal, Quebec, Canada, 3-6 Sept. 1974 (Montreal Quebec, Canada: Univ. Montreal 1974,), pp. 16/5a-5b.

Describes a technique, making use of both guarding and double insulation, which reduces the shock hazard of electromedical apparatus. The technique is suitable for use in treatment areas where both the patient and the electrical supply system are connected to ground. The addition of a guarded, double-insulated power input circuit to each piece of electromedical equipment prevents current from flooding from the power source to the grounding circuit, and makes an equipotential ground possible in a patient area.

Grounding Circuits--Methods of Measurement and Effectiveness; M. B. Raber (Univ. Manitoba, Winnipeg, Canada) - Fifth Canadian Medical and Biological Engineering Conference--Digest of papers Montreal, Quebec, Canada, 3-6 Sept. 1974 (Montreal, Quebec, Canada: Univ. Montreal 1974), pp. 16/1a-1b.

It is becoming common to measure resistance or continuity of grounding circuits by impressing a high current on the circuit. It is not generally appreciated that if the circuit is wholly or partially within steel conduit, the resistance so measured is dependent upon the circuit path. Experimental results show why a local equipotential grounding grounding system appears safer than ordinary conduit grounding, though it may be less effective in fault current return. Implications for patient care areas are discussed.

Stratified Earth Effects on Wave Propagation Frequency-dependent Parameters; A. Ametani (Univ. of Manchester Inst. Sci. & Technol., England) - IEEE Trans. Power Appar. & Syst. (USA), Vol. PAS-93, No. 5, pp. 1233-1239 (Sept.-Oct. 1974).

Stratified earth effects on wave propagation are investigated using a three layer earth impedance with arbitrary earth resistivities, permeabilities, and permittivities. Significant differences are observed between homogeneous earth and stratifier earth cases. It appears to be necessary to account for the stratification of a real earth in the calculations of frequency-dependent parameters.

Ground Fault Tests on a High Resistance Grounded 13.8KV Electrical Distribution System of a Modern Large Chemical Plant (Arcing); L. B. McClung, B. W. Whittington (Union Carbide Corp., South Charleston, WV, USA) - IEEE Trans. Ind. Appl. (USA), Vol. IA-10, No. 5, pp. 601-617 (Sept.-Oct. 1974).

Actual ground fault tests were conducted to determine the behavior of low magnitude arcing ground faults in a closed air-filled 13.8KV terminal chamber. Ground current magnitudes between 10 and 50A were allowed to flow under various ground fault conditions. At higher ground fault current levels the ionization of the air-filled chamber progresses at a rapid rate, and the arc is sustained or phase to phase faulting quickly occurs. The practical consideration appears to be that if ground fault current can be limited to 10A or less then initial ground faults will either clear themselves or create solid ground paths. This can allow the system to operate until an orderly shutdown procedure can be initiated.

Conductive Gasket; J. A. French, S. P. Kle zkowski, J. A. Kornfeld, H. Trynoski (IBM, New York, USA) - IBM Tech. Disclosure Bull. (USA) Vol. 27, No. 5, p. 1304 (Oct. 1974).

The gasket is a flexible, carbon filled silicone compound moulded into a U-shape and fastened to one side of a cover or frame with clips or adhesive. When the gasket is squeezed between the cover and frame, electrical and mechanical contact occurs despite very low closure forces.

Earth Loop Testing and p.m.e. Systems; S. R. Freeman - Electr. Times (GB), No. 4301, p. 15 (10 Oct. 1974).

Outlines the development of protective devices since 1930's. Discusses the importance of installing sensitive current balance trips. Questions some aspects of protective multiple earthing; e.g., the hazards in the event of breakage of the neutral connection. Suggests that a regular test of p.m.e. installations with a line-earth tester is needed. Outlines the development of a universal tester with combined test facilities.

Electrostatic Fields Underneath Power Lines Operated at Very High Voltages; R. N. Allan (Univ. Manchester Inst. Sci. Tech., England) - Proc. Inst. Electr. Eng. (GB), Vol. 121, No. 11, pp. 1404-1408 (Nov. 1974).

The intensity of the electrostatic field at ground level due to transmission lines operating at 765, 1100, and 1500KV have been calculated as a function of lateral distance under the line. These results showed that the maximum field varied from 15 to 20KV/m. It was found that this field could be reduced significantly by interposing earth shield wires between the line conductors and earth; the intensities being most affected by the number of wires. It was also shown that a nonuniform distribution of these wires is essential to ensue maximum effectiveness. However, because these shield wires add nothing to the operation of lines, but will add to their cost, it is necessary to define values of fields that can be tolerated at ground level.

Application of Probability Calculations to the Study of the Earthing Voltage Requirements for Electrical Safety Codes; S. Karkkainen (Oy Nokia Ab Finnish Cable Works, Helsinki, Finland), V. Palva - Sachkoe (Finland), Vol. 47, No. 11, pp. 463-471 (Nov. 1974); in English.

This article is concerned with the determination of requirements related to earthing system voltage, these requirements being one of the main subjects under review in the new electrical safety code. For the first time this is performed with the aid of probability calculations. Various practical cases are classified in groups, the maximum permissible voltages of which are determined on the basis of accident probabilities of certain values. In the calculations, general stress-strength considerations are made use of. Hereby are taken into account the frequencies of occurrence of various danger situations as well as the calculated probabilities of being exposed to touch and pace voltages.

Isolating Power Supply Lines Avoids Problems with Earthing; E. B. Piercy, M. J. Scott (Taylor Instrument Co., Europe, Ltd., London, England - Control & Instrum. (GB), Vol. 6, No. 10, pp. 50-51 (Nov. 1974).

The authors take a positive look at the "common negative" approach for connection of electrical power supplies.

Shielding Properties of Thick Conducting Cylindrical Shells; Te-Kao Wu, LiLi Tsai (Univ. Miss. USA) - IEEE Trans. Electromagn. Compat. (USA), Vol. EMC-16, No. 4, pp. 201-204, November 1974.

The shielding properties of a thick cylindrical shell of finite conductivity is presented. The analysis uses straightforward separation of variables methods via cylindrical harmonic functions. The results show that significant attenuation of the incident fields are achieved for thick cylindrical shields thus demonstrating that the resonances noted in earlier work using thin shell models can be alleviated.

Grounding and Safety; D. J. Hatch, M. M. B. Raber (Health Scis. Centre, Winnipeg, Man., Canada) - IEEE Trans. Biomed. Engr. (USA) Vol. BME-22, No. 1, pp. 62-65 (Jan. 1975).

Several basic facts about the effects of steel conduits in a.c. power systems are reviewed to show that the geometry of a grounding path may have a greater impact on its effectiveness as a ground return path than its d.c. resistance. Data are presented on the effect of 1/2" E.M.T. conduit and No. 10 conductors in tests simulating regular room wiring under ground fault conditions. It is shown that an internal grounding conductor tied to the conduit produces the lowest practical limit to voltage differences in the ground circuit; additional grounding paths external to the conduit make little appreciable difference to the voltage rise due to a fault current. A separate grounding conductor external to the conduit, when used by itself, produces a much larger voltage rise than the conduit system.

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